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Genome editing is new genetic engineering

Genetic engineering, commonly called genetic modification, leads to the creation of genetically modified organisms (GMOs). This includes the new techniques of genome editing.

Genetic engineering is a set of laboratory techniques that are used to change the characteristics of organisms, resulting in genetically modified organisms (GMOs).

Genetic engineering makes changes to an organism by **directly intervening in its genetic make-up**, without mating. Genetic engineering techniques are used to insert new genetic material or to induce changes to targeted DNA sequences. They can also be used to delete and rearrange DNA, for example. The techniques are powerful but can also result in unintended changes to an organism.

The processes of genetic engineering enable humans to intervene directly in the genome (the entire set of an organism's genetic material) of organisms, which was **not possible before this technology**. For example, the first generation of genetic engineering tools were used to insert additional genes into the genome of an organism, taken from any organism, even from entirely different species. More recently, with the genome editing technique of CRISPR/Cas, scientists can intentionally cut strands of DNA within cells, to initiate changes.

With new techniques of genetic engineering, humans can make **ever deeper and more complex changes** to the genetic makeup of living organisms. For example, with genome editing, genetic sequences that are otherwise carefully protected by an organism against random mutations, can now be targeted and modified. Genome editing can also be used to change all the copies of one gene or many different DNA sequences at once. Artificial intelligence further enhances the power of genetic engineering to redesign organisms. The magnitude of changes that are possible is dramatically and profoundly expanding all the time.

Genetic engineering gives humans unprecedented power to make changes directly to the genome of an organism even though our knowledge and understanding of genetics and organisms is incomplete and still growing.

GENOME EDITING

Genome editing, also called gene editing, is **a powerful new set of genetic engineering techniques**. The techniques aim to alter a specific, targeted DNA sequence, by deleting, adding or replacing some of its components. The most frequently used genome editing technique in experiments is CRISPR/Cas, but other techniques follow similar principles.

Genome edited organisms are genetically modified organisms (GMOs). However, there are many imprecise and confusing terms and definitions being used around the world to describe and regulate genome-edited organisms, and many of them lack a solid scientific basis. There is, however, no dispute in the global scientific community that genome editing techniques are techniques of genetic engineering. For example, Jennifer Doudna, one of the developers of the genome editing CRISPR/Cas-9 method, refers to CRISPR/Cas as "genome engineering."

These new techniques of genetic engineering raise many of the same **risk questions** as earlier techniques did, as well as some new ones. They also raise the same environmental, social, economic and ethical concerns.

How genome editing works

Genome editing systems are comprised of molecular components that are programmed to make changes (perform "edits") at a target DNA sequence.

Generally, genome editing involves the insertion of genetic material that works inside the cell as a set of instructions to produce the CRISPR/Cas guided DNA cutters. The CRISPR/Cas complex is made up of two components: the ability to recognize and attach ("dock") onto a specific DNA sequence (CRISPR), and the activity to cut the DNA at that place (the "molecular scissors") (Cas). Other components can be added to try to instruct the cell on how to repair its cut DNA.

Genome editing, generally, uses molecular DNA cutters that are guided to a specific DNA sequence in an organism, to cut the DNA (to create a DNA double strand break). When DNA is cut, the cell recognizes this cut as an injury and urgently sticks the broken DNA back together using its own repair mechanism. This repair makes mistakes, which are the "edits" to genes that may result in new, desired characteristics, but can also result in unexpected changes. The genome editing system can also be used to try to direct how the cell makes these repairs, and to delete whole genes.

Until now, genetic engineering created new DNA sequences by inserting genes which then became a permanent part of the GMO, to create the new desired characteristic. With genome editing, however, the genetic material that is inserted to trigger "edits" does not need to remain in the, now genetically modified, organism. This is why **many GMOs developed through gene editing do not have any "foreign DNA"** (DNA from other species).

Unexpected effects of genome editing

Genome editing is often said to be more precise than earlier methods because the changes occur to target DNA sequences whereas earlier techniques led to the insertion of genes at random places. However, **gene editing can be imprecise and, like other genetic engineering techniques, cause unexpected and unpredictable effects**.

Gene editing can create genetic errors in the GMO either due to the action of the DNA-cutters or due to the other processes involved. These effects can lead to unexpected and unpredictable outcomes, such as changes in protein composition and altered behaviour in and of the organism.

- The CRISPR system can make unintended edits to DNA at unexpected places, not just the target sequence.
- Genome editing can cause extensive deletions and complex re-arrangements of DNA at or near the cutting site.
- Unwanted DNA can unintentionally integrate into the host organism during the genome editing process.

Despite the power of genetic engineering to change the characteristics of organisms, there are many gaps in our knowledge. The interactions between the genes themselves, as well as the interactions between genes and the cell, the organism and the wider environment, are highly complex and not yet fully understood. There are many changing factors that make the outcomes and consequences of genetic engineering, for the genetically modified organism as well as for the environment, unpredictable.

For more information:

Genome Editing in Food and Farming: Risks and Unexpected Consequences, Canadian Biotechnology Action Network, 2020. https://cban.ca/genome-editing-in-food-and-farming-risks-and-unexpected-consequences/

Gene Editing Myths and Reality, 2021, https://extranet.greens-efa.eu/public/media/file/9065/6768

When chatbots breed new plant varieties: Generative Artificial Intelligence and New Genetic Engineering Techniques, Save Our Seeds, 2025. https://www.saveourseeds.org/publications/when-chatbots-breed-new-plant-varieties/

cban.ca/genome-editing

The Canadian Biotechnology Action Network (CBAN) brings together 15 groups across Canada to research, monitor and raise awareness about issues relating to genetic engineering in food and farming. CBAN is a project on the shared platform of MakeWay Charitable Society.

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